G 4

A NATIONWIDE HIGH-SPEED MONORAIL GRID FOR THE UNITED STATES

TECHNICALLY FEASIBLE?
ECONOMICALLY VIABLE?
ENVIRONMENTALLY DESIRABLE?
POLITICALLY ACHIEVABLE?

By Thomas H. Hopkins

11/13/2001

The US built the railways in the 19th Century, and it built the highways and airways in the 20th Century. These systems are straining. Now in the 21st Century, it is time for the US to build a fourth nationwide transportation grid, G4. G4 will be a guideway system for the high-speed monorail. It will provide intercity and metro transportation, a seamless unimodal system, for both people and freight. But mainly it will be a high-speed transit system for people and will operate at over 250 MPH in intercity applications, and at 125 MPH in metro applications. I'm going to suggest a vision that touches on the technology, economics, environmental aspects, and politics of very high-speed transit.

CONGESTED HIGHWAYS & AIRWAYS.

When I use the term "transit" system, I am referring to a fixed guideway system which carries passengers, be it a city system that stops every block, a metro system with stations several miles apart, or a high-speed intercity system with stations 50 to 100 miles apart. Two questions have been gnawing at me:

- Is there any major city in the world in which traffic congestion is not a problem?

I have asked many people this question and, to date, no one has volunteered a single major city in which congestion is not a problem. I'm sure there are at least several such cities, but there can't be many. Traffic congestion appears to be a universal problem, a turn of the century curse.

- Has a congested highway ever been widened and then remained uncongested for a significant number of years?

Typical US Highway in 2001

I have received a few answers to this one, e.g., the Tristate around Chicago. But for every example of a successful widening, there must be ten unsuccessful ones, where a widened highway was almost immediately congested. It seems that widening a highway contains the seeds of its own defeat; that it induces more traffic growth and pretty soon, we are back where we began with still more congestion. Widening, widening, and widening roads is not the solution.

The situation is not much better with the airways, with US air travellers suffering unprecedented delays summer 2000, and many now too frightened to fly. It takes longer to fly from Atlanta to New York in 2001 than it did in the late 1950s. Much more time is spent on the ground going through security, waiting for a take-off slot, and circling in the air waiting for a landing slot.

It seems that transportation policy makers almost despair that they face a massive problem for which there is no apparent solution. I would like to offer hope. I see a solution and I suggest that the first half of the 21st Century may be a second golden age for transit systems. There are two components to this second age of transit:

- High speed intercity systems capable of 250 MPH or more and effectively serving city pairs which are up to 600 miles a part.

- High-capacity metro systems, capable of delivering 1,000,000 passenger miles (number of passengers times the average speed) per hour per direction.

These systems could be connected into a national grid, G4. Perhaps some day cyber-commuting, cyber-commerce and cyber-entertainment will obviate our need to go places, but that appears to be some time off. The main difference between this second golden age of transit and the first one is that there will now be an emphasis on speed, very high speed. Instead of ambling along at a pace that would only impress people used to the horse and buggy at the start of the 20th Century, these new transit systems must run at 250 MPH or higher, necessary to win riders in the first half of the 21st Century.

CRITERIA & GOALS.

For this vision to be realised, the US needs a system which will attract riders, which is economically sound, which is environmentally desirable, and which can win the support of political leaders and the public. The criteria I suggest are:

- ***Technically Feasible?*** G4 must attract many drivers, i.e., a lot of people who presently drive must give up their cars and start to ride the transit system. Unless we can get people out of their cars, we won't relieve congestion on the roads and hence won't improve conditions for those who still want or must drive. A conventional transit system is slow and so will only divert 5% or less of daily traffic (more during rush hours in some corridors), thus having minimal impact on reducing traffic congestion. This is not nearly enough - we need to divert 25% of daily traffic to significantly reduce congestion. Achieving this is largely a technical issue, and I will discuss technologies that are fast. High-speed operation is necessary for success in both intercity and metro systems.

- ***Economically Viable?*** G4's economic viability must be sound. A lot of transit systems are subsidised because they are just not viable as too few people ride them. An acid test of viability is whether the private sector will risk its capital to build and operate the system. A goal would be to have the 80% of the capital cost paid for by the private sector. I do not think we can wait for or rely on the federal government to pay for our transit systems. So I'm going to discuss some economic issues

- ***Environmentally Desirable?*** G4 must promote "good growth". By this, I mean that future developments will be more concentrated and in areas which are already built-up, and they will promote transit use. "Sprawl" and still more car use are to be avoided. An ambitious goal might be for 50% of future developments to be such good growth. So I'm going to touch on some environmental issues.

- ***Politically Achievable?*** To happen, G4 has to win political and popular support. This is a bigger task that winning riders, we have to win non-riders too. To succeed, a transit system probably needs a powerful sponsor, a political leader who can win the votes. A majority in the legislature is probably needed, and in this age of ballot initiatives and referenda, a majority of the public needs to be for the system. Finally, I'm going to rush in where angels fear to tread and give an Australian's view of the US political scene on transit issues.

I now turn to see if there is any way that a transit system could satisfy these criteria and achieve these ambitious goals. I look at the technology, economics, environmental aspects, and politics

TECHNOLOGY

Transit has been in a fifty-year decline. Why? Cars have steadily become more convenient, fast, and affordable and this is an obvious reason. But, I suggest that another reason has been the failures of the transit industry. The transit industry has not developed transit systems that offer the convenience or speed of the automobile. Instead, it has relied on technology with its roots in the 19th Century - I refer to conventional rail systems. Alternatively, it has offered an exotic technology that is uneconomic or won't work. I refer to maglev.

Conventional intercity trains. One component of G4 would be to expand Amtrak's high-speed service using the Acela, an Americanised version of France's TGV and capable of 150 MPH.

TGV

There are three problems with this proposal:

- Amtrak runs its trains on privately-owned freight rail tracks. In many places these are at or near capacity and the freight companies object to giving priority to passenger trains so that they can maintain a schedule. Further, freight tracks are not maintained to the high levels that are necessary to run at very high speeds. Providing a new dedicated right-of-way would be prohibitively expensive.

The problem with conventional rail transit systems is that they are too slow and they are not elevated.

- Conventional trains are too slow - the fastest is the TGV which runs at 186 MPH. To be really competitive between cities up to 600 miles apart, the trains need to operate at over 250 MPH. Conventional train technologies are at about their technical limit, and such speed improvements will come very slowly and expensively.

- The freight railway tracks are at grade and so there will always be the issue of safety at grade crossings. By not being elevated, conventional trains will always face safety issues and speed restrictions. Conventional trains are so heavy it would be prohibitively expensive to elevate them throughout their route.

Conventional light rail. G4 is both an intercity and metro transit system and so we need to examine light rail which is a common solution for metro transit systems.

Light Rail

It's a hassle to take a transit system. First you have to get to the station, then buy a ticket, then wait for the train, and finally, when you arrive at the destination station, you have to get from there to where you are actually going. Why would anyone go through this pain? For most people, it is so much more convenient to take their own car. The only reason most people would take a transit system is if there is some very big advantage that more than offsets the hassle.

The problem with many conventional rail transit systems is that they are too slow. So not only is a person expected to go through all of the hassle of getting to and from the station, he is expected to then spend a long time on the vehicle, longer than if he simply drove himself, even with all the traffic. The fundamental problem of conventional rail systems is that they rely on traction between their steel wheels and the steel rail to accelerate and to brake, so they do so slowly. In Colorado, a light rail system is being planned for I-25, connecting Denver metro to the area south. If it stops at every station, as planned, then it is projected to run at an average speed of just 14 MPH. People will only ride it if highway congestion and downtown parking remain quite impossible.

The second issue with conventional trains is the low passenger carrying capacity, caused by the limited emergency braking system. Again, this relies on traction between the steel wheels and rails, but the braking forces which can be generated are limited by the weight of the vehicle. This means that a conventional train can only stop slowly in an emergency and so the required headway, the time between trains, is long. Thus a conventional train system has trains widely spaced and so a low people-carrying capacity. The light rail system in Colorado along I-25 is projected to have a capacity equivalent to slightly more than one highway lane in each direction, but it will move people at half the speed of cars on the congested highway. In the big scheme of things, it will have little impact on reducing congestion.

Conventional rail solutions are not going to cut it in the 21st Century.

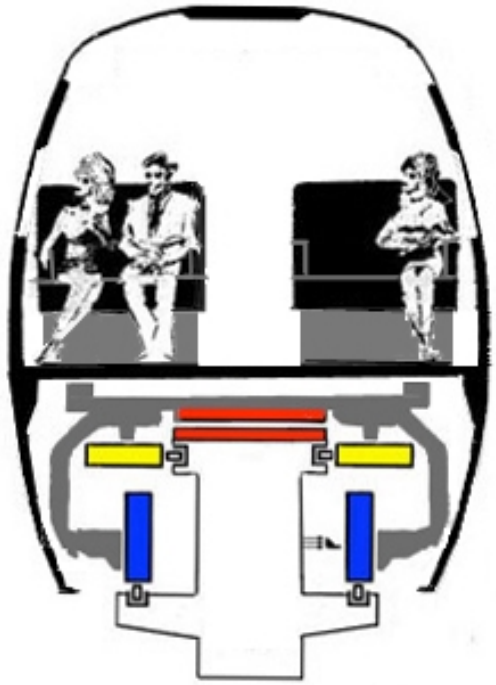
High-Speed Monorail.

I think there are three important attributes for a 21st Century technology: 1) the ability to run at high average speeds safely, 2) high passenger carrying capacity, and 3), the ability to follow a highway right-of-way, i.e., to take tight curves at high speed.

High-Speed Monorail

There may be a number of solutions that will satisfy these criteria, but I am very familiar with one, the high-speed monorail. This is the system that the Colorado state agency, the

Colorado Intermountain Fixed Guideway Authority (CIFGA) proposed to use from Denver up I-70 to the mountain communities. A similar vehicle was first developed by Dr. Julio Pinto in Spain in the late 1980s. It wraps around the guideway beam and the load is carried by one set of flangeless wheels and the vehicle is guided by another set of wheels mounted horizontally to run on the sides of the guideway beam. The monorail is propelled by a linear induction motor; there are several motors available, but the one we proposed was the Seraphim motor developed by Sandia National Laboratories. Normal braking is accomplished by putting the motor in reverse, while the emergency brakes are pneumatic with opposed surfaces that grip with great force onto the rails, acting rather like the disk brakes on a car. The guideway is precast concrete and is cast off-site and shipped in and erected in the early morning hours, minimising disruption during construction.



Cross-Section of High-Speed Monorail
Blue: load-bearing wheels, Yellow: guidance wheels, Red: Seraphim motor

The performance of the high-speed monorail is excellent:

- It is very fast. It can accelerate at the maximum rate at which people are comfortable, it can run at speeds in excess of 250 MPH, the track can be steeply banked and so it can handle tight curves at high speeds, and it can quickly brake to stop at the next station. Even when the monorail is being used in a metro application with frequent stops, it can run at higher average speeds than automobiles on the highway. In the Colorado application, it could move people the 100 miles from Denver to the mountains in one hour, much less than the two hours it takes to drive in good conditions or three hours in congested conditions.

- It is safe, even at very high speeds. At 250 MPH, the amount of kinetic energy is enormous and so safety is a dominant consideration. The monorail wraps around the guideway, it has a very low center of gravity (just 28" above the guidance wheels), its wheels are lightly loaded and flangeless so there is little chance that a wheel can be damaged and shatter, and the whole vehicle is mechanically entrapped on the beam, preventing derailments. Because the monorail is elevated, the issue of at-grade highway crossings is moot.

- It has high people carrying capacity. Because its emergency brakes can stop the vehicle in much less distance than the emergency brakes on any conventional train, the monorail can run at tight headways even when operating at high speeds. The system could run monorails carrying 1,000 passengers at speeds of 125 MPH with headways as little as three minutes. This gives a capacity of 20,000 people per hour per direction. Even more impressive, it can do this while averaging over 50 MPH in a metro application with frequent stops and starts, giving the ability to deliver 1,000,000 passenger miles per hour per direction (20,000 pphpd times 50 MPH). I don't know of any other system that comes even close to moving so many people at such a high average speed.

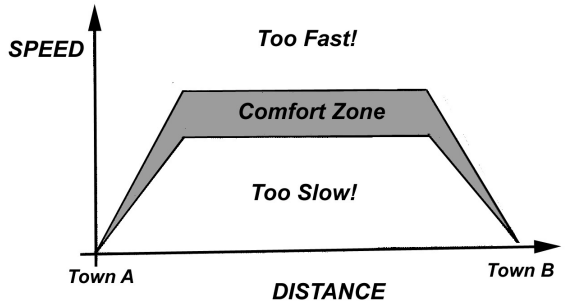
- It can follow a highway right-of-way because of its ability to take tight curves at high speed. In this age of high density metropolitan areas, acquiring new right-of-way is not often an option.

Will it attract many passengers? The Colorado Department of Transportation tested this for the proposed 168 mile system connecting metro Denver to the mountain communities (Vail, etc.). They interviewed 4,167 people who had just driven i-70 and found that an incredible 63% said they would consider riding the high-speed monorail instead of driving. CDOT tested the various markets and found that many drivers "certainly would" or "probably would" ride the

monorail instead of driving. Only a small number of people would even consider riding a bus or van.

The high-speed mono-rail is a technology that could be good for the entire 21st Century.

The Zone. There is a zone within which a transit system must operate to be attractive. If the system is too slow, few will ride it. If it is so fast that it is uncomfortable, few will ride it.



Comfort Zone

The above diagram plots speed against distance for vehicles running from Town A to Town B. Most conventional rail systems operate below the zone, are too slow, and have little chance of ever being made fast enough to get into the zone where they would attract passengers. The high-speed monorail is so fast, it could operate above the zone. Fortunately, it is an easy matter to slow the high-speed monorail so that it operates within allowable lateral acceleration rates, etc. and is comfortable for passengers. It operates at the top of the zone.

People's comfort level changes with time. While people at the start of the 20th Century were not comfortable with fast cars (early cars had to be preceded by a man ringing a bell), now people routinely speed down the highway at 75 MPH. As people become more accustomed to the high performance of the monorail and comfort standards are relaxed, the high-speed monorail could operate at faster and faster speeds. The high-speed monorail is a technology that could be good for the entire 21st Century.

Maglev. The transit industry is developing another technology to meet the needs of the 21st Century, maglev. Unfortunately, maglev is sucking up money and has been dragging us in a direction that is a dead-end. Maglev, in which the vehicle is magnetically levitated above its track, was heralded in the 1970s as a technology that would allow vehicles to float rapidly down a guideway without any of the rolling friction or safety problems that wheels then presented. The US has spent millions on this technology, and the Japanese and Germans have spent billions more. All to no avail; we still do not have a viable revenue-generating system anywhere in the world and in early 2000, the German government withdrew its support for a Transrapid demonstration project to be built from Hamburg to Berlin. It was not economic and it had lost political support.

Unfortunately, the US is flirting with maglev and is now considering spending close to one billion dollars to build a demonstration Transrapid system, the German maglev technology, in either Washington/Baltimore, or Pittsburgh.

In the paper, *Maglift Monorail,* which I coauthored with Dr. Pinto, Spain, and Mr. Kelley and Drs. Marder and Turman of Sandia National Laboratories, we compared the German Transrapid TR07 maglev with the high-speed monorail. We found that not only does maglev cost more to build than the high-speed monorail (about double), but it is more technically complex, costs more to maintain, and its energy costs per passenger mile are 66% greater.

Transrapid TR07

For a new technology, such as magnetic suspensions, to take over from a well-established technology such as wheeled suspensions, there has to be a compelling advantage, or it is just not going to happen. What is the advantage of magnetic suspensions? There are none. The high-speed monorail is projected to be as fast, safe, quiet, and comfortable. More importantly, it is much less expensive to build, run, and maintain, it can take tighter curves allowing it to follow a highway right-of-way, uses an off-the-shelf decentralised control package, and allows tighter headways

and longer trainsets giving greater passenger-carrying capacity.

The fundamental assumption of maglev proponents, that wheels are bad, is wrong. Wheels are a proven technology and new flangeless designs with high performance bearings carrying light-weight vehicles makes their safety and performance excellent.

Maglev does not have any compelling advantages. In fact, it has several compelling disadvantages. The economic proposition of maglev is to spend billions extra up front in order to pay millions more each year in operating costs. It will never fly!

ECONOMICS

The fundamental problem with transportation in the US is that there are too many drivers and too few riders. Why are people so keen on driving their cars, and so reluctant to ride transit systems? There are at least two reasons:

- Driving is so convenient. With a car, you can leave from your own home precisely when you want and you can drive to precisely where you want to go. Compared with this, using a transit system is a hassle. Even with the increasing congestion and difficulty in finding a parking space, driving is still more convenient than riding for large segments of the population.

- Riding costs out-of-pocket money while driving is "free". People typically pay about $300 per month for their car, and another $200 for gas, and for this they have wheels for the month. Most people think of these car costs as fixed costs and few seem to think of the incremental cost of the gas actually used or the wear and tear when considering a trip. On the other hand, if you ride, you have to pay money out of your pocket and that's a deterrent.

FAT Corridors. The vagaries of the political process suggest that, to become widespread and successful, high-speed transit systems must become the business of the private sector rather than the government.

A solution which may help reverse this drive Vs ride preference, and place the private sector into a leading role, is FAT corridors (**F**ree transit **A**nd **T**olled highway). The FAT corridor concept is simple – charge anyone who drives a toll, and use the toll money to make riding the transit system down the same corridor free. I believe that to really change the dynamic of drive Vs ride, the US needs to do something this drastic. Congestion pricing is just nibbling at the problem and just better allocates use of the highway, but it does not increase its raw capacity and congestion won't be solved until raw corridor capacity is increased (and growth of demand stopped).

The private sector would play the leading role as the transit system down a corridor would be financed with FAT bonds purchased by the private sector and serviced by the tolls on the highway.

The FAT corridor concept is simple – charge anyone who drives a toll, and use the toll money to make riding the transit system down the same corridor free.

The FAT corridor concept was discussed informally with several employees of the Federal Highway Administration. Under current law, Federal highway funds at the discretion of a state could be used to support FAT transit capital construction costs in a corridor, but not transit operating costs. That would require a change in the law. There are also likely limitations under state law relating to the setting of tolls.

Typical Congested Highway
Eight Lanes: Capacity 20,240 People/Hour

FAT Corridor
Eight Lanes & Double Guideway: Capacity 60,240 People/Hour

If FAT corridors were used, the results would be dramatic:

- Ridership would be up and driving would be down. Many people would be attracted to the transit system if it cost nothing to ride, and especially if it delivers you there in less

time than it takes to drive on the tolled highway.

- FAT corridors would not require a government operating subsidy as the people using the corridor are paying for the free transit by paying the toll on the highway.

The capacity of the corridor would be significantly increased, solving the problem for many years to come. This is no temporary fix.

For-Profit Operator. Transit systems have the reputation of being inefficient and unprofitable. During the Colorado legislative hearings for the high-speed monorail, one legislator stated that there are no profitable transit systems anywhere in the world – they all require government subsidies. This is not true; there are many profitable transit systems. The national Japanese and British train systems have been broken into smaller for-profit operations and many of these systems are now profitable. The key seems to be to have for-profit companies as the operators.

ENVIRONMENT

The energy consumed to move people around on a transit system is clearly less than with automobiles. We estimated that the monorail when it is just half full of passengers uses less than 1/7th the energy per mile per person used by automobiles.

Consider a City-Pair connected by a major highway and where not much green-field development has yet occurred. The issue is what pattern of growth is going to occur in the coming years?

Often it is decentralised growth with green-field developments in the open spaces between the cities. This is sprawl and results in congested highways which are being forever widened. It is interesting that the Texas Transportation Institute concluded that neither population growth nor too few roads are to blame for traffic congestion. Their analysis finds that traffic congestion is getting worse because of sprawl. It's not the number of people that is the problem,

it's the increased average driving distance. A typical decentralised growth pattern in which green-space is developed early and the space between cities is gradually filled with low density development, similar to what happened around Los Angeles, could be represented by the following diagram.

The problem with this approach is that it front-loads the infrastructure and service expenses, and increases the average distance that people travel, causing highway congestion.

Conventional Growth

ADRs. A typical scene in a metro area is a congested multi-lane highway running down a canyon of mid-density developments.

The government has an asset in the air development rights (ADR) over the major transportation corridors, and these could be sold. The idea is to cover sections of the highway and to build on top a transit station plus a high-density, multi-function development with homes, offices and shops. There are several positive effects:

- The government benefits from the sale of an otherwise unused asset, and the proceeds could be used to help pay for the transit system which runs down the corridor.

- High-density development takes place around the transit stations and so the growth that results would not increase highway congestion.

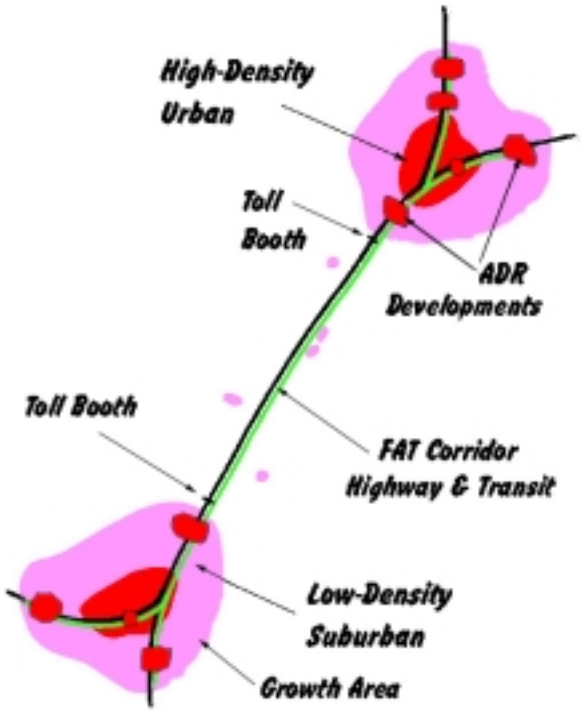
- The development is within easy reach of existing infrastructure, and so would be less expensive to support than green-field development.

- Noise from the highway is reduced as it is covered, and surrounding neighbourhoods become quieter.

Typical Highway with Air Space

FAT Corridor & ADR Development

Good Growth. ADR developments combined with FAT corridors would be powerful weapons to promote "good growth", meaning growth which is high density and within the confines of a metropolitan area, not decentralised growth in the green space between cities. The toll booths for the highway could be placed on the perimeter of the area where dense development is being promoted so that people living and travelling within this area pay no tolls, while those who live in green-field developments outside pay a toll for using the highways. This growth is preferable as it costs much less in services and infrastructure to support, and it generates less congestion as travel distances are shorter. Such a growth pattern could be represented as follows:



FAT & ADR Growth

The environmental advantages of this approach are many. Automobile use with its noise and exhaust pollution is reduced, less energy is used to move people around, the highways are less congested making driving a more pleasant experience, development is less expensive as it is more centralised (and dense) and can be supported with incremental additions to existing infrastructure.

The beauty of this approach is that it sets up economic incentives to control sprawl. People act on their own self-interest, and that happens to coincide with actions that are good for the environment. This may be preferable to relying on constitutional amendments to control growth (as Colorado attempted in a ballot initiative that was defeated in November 2000) or on regulation. These political approaches generate considerable opposition and there are often unintended consequences.

ADR developments combined with FAT corridors would be powerful weapons to promote "good growth"

POLITICS

I'm an Australian who is considered an "alien" in this country, so I hope my comments on the US political scene with regard to transit will be seen as non-partisan. It may not be "politically correct" to discuss the politics of transit, but I don't think we'll make much progress until we recognise where people

are coming from and attempt to address their issues.

Sponsor. A major transportation project needs a powerful political sponsor, and it does not need a powerful opponent. Colorado has Denver International Airport because Denver's former mayor, Frederico Peña, stepped up and led us there, despite all the nay-sayers. The high-speed monorail for Colorado's I-70 is not on the ballot this November because Governor Owens managed to derail it at the last minute in the Colorado legislature. You'd think that a major political leader would step forward and sponsor a high-speed monorail project - it offers the potential of a "signature project", one which could make the reputation of the sponsor.

Republicans don't like things that don't work! And many transit systems don't work – they have minimal impact on reducing congestion.

FRA. The Federal Railroad Administration has charge of the billion dollar high-speed maglev program approved in TEA-21. I wrote to the FRA in May, 1999, and asked if the high-speed monorail might qualify as a form of "maglev" for the purposes of their program. The high-speed monorail never lifts off the guideway (thereby avoiding a host of technical problems), but the linear induction motor could be positioned to give magnetic lift and guidance as well as magnetic propulsion. Fortunately the FRA agreed, and they consider the monorail a form of maglev for the purpose of their program.

Democrats & Republicans. On the Colorado high-speed monorail project, three quarters of the Democrats in the Senate voted for the project, but two thirds of the Republicans voted against. This breakdown may be fairly typical of Democrats and Republicans in general. Democrats tend to be visionary and environmentally sensitive, so they are for transit. Notwithstanding the above statistics, some Republicans are strongly pro-transit; Colorado's state agency, CIFGA, was established by a Republican legislature and some of its leading members are conservative Republicans. However, to have a new age of transit in the US, it will be necessary to win the votes of more Republicans. Why are the majority of Republicans against transit? I don't think transit is considered a "socialist plot" to subsidise poor people or to restrict where you can travel. I think there are three very real reasons.

- Pragmatism. Republicans don't like things that don't work! And many transit systems don't work – few people ride them and so they have minimal impact on reducing congestion. Thank the Republicans that we are not saddled with lots of conventional transit systems that few people ride, or maglev systems which are uneconomic. The high-speed monorail is an integration of existing technologies and so its development is not a high risk proposition.

- Small government. Republicans don't like big government solutions and so much of mass transit smacks of big government. However, Republicans may like the idea of FAT corridors, selling ADRs, and for-profit operators. In these, the private sector takes the lead and the government plays a facilitating role. Now that the federal budget is in surplus as far as anyone can see, new issues of government bonds will dry up. Perhaps the AAA bonds of the future will be FAT bonds, serviced by highway tolls, and guaranteed, partially at least, by the federal government. It would take hundreds of billions of dollars to build all the systems needed. Issuing and trading FAT bonds could become an important financial market.

- Corporate constituency. Republicans tend to represent corporate interests and corporations want to preserve their business, defend the status quo. A bird in the hand is actually worth ten in the bush. On the Colorado project, we were out-lobbied by the highway and bridge builders, the Asphalt Institute, and the automobile, and trucking interests… everyone who saw this transit project as a lost highway project. Our consortium, made up of one international contractor, one international engineering consultant, and one international bank felt that the project had too much "blue sky" (it had to pass two statewide votes) to warrant serious money being spent on lobbying. I think some Republican support will not materialise until the emergence of a powerful group of companies which are benefiting from transit projects and which exert political influence. This is a chicken and egg problem. The challenge is to break through, perhaps by generating an exciting and big vision that corporate America will buy into.

Considering that the high-speed monorail will attract many passengers, that its development is not high risk, and considering the leading role

envisaged for the private sector, it may be possible to win the support of a majority of Republicans in the fairly short term. It's time for Republicans to reconsider transit and take a look at the high-speed monorail.

People Vote for Monorails.

Public. The good news in all of this is the popularity of the high-speed monorail. Whenever a monorail has been put on a ballot alongside other transit solutions, the monorail has always won easily. People love monorails. In Colorado, the high-speed monorail proposed for I-70 enjoyed lots of positive press and was very popular with the people. However, it recently (November 6, 2001) lost a statewide ballot for $50 million for its development. In early September it enjoyed favorable poll ratings of 83%, but following the terrorist bombing, war, Antrax scare, and rapidly worsening economy, it dropped rapidly in the polls and was defeated, along with all other money requests on the ballot that year in Colorado. I hope this was an aberration

I mentioned earlier that I really don't think we'll solve the problem until we toll car use and have free transit, i.e., FAT corridors. People may vote for the high-speed monorail, but will people actually vote to toll themselves by implementing FAT corridors? I can give three reasons why they might:

- Less congestion. People who want or who must drive will be pleased to get those other people off the highway so that they have a clear shot on an uncongested highway. Happy driving!

- Free and attractive alternative. Many people will be attracted to a free and fast monorail. I can ride the monorail for nothing and get there in less time than I could driving. No tolls would be charged until the free monorail was in place.

- Many voters won't pay the toll. By locating the toll booths on the perimeter of the metro area, the many voters who live within the metro area would rarely pay the toll. It would be paid by interstate travellers, truckers, and people who insist on living in low-density green-field developments between the cities. But not by me!

There is a powerful reason why people may not vote for transit systems, despite the popularity of the high-speed monorail. If it appears that such transit systems could become widely adopted, the lobbying against them by the automobile industry, the road and bridge builders, the asphalt manufacturers, the truckers, the airlines, and the oil and gas producers could become intense. The car-highway-oil-airline complex is much more powerful than the military-industrial complex (that President Eisenhower warned against) ever was. It is how many Americans earn their living, and they might fear that that living would be jeopardised.

I think that people would vote for the high-speed monorail, but would not vote for FAT tolls to finance its widespread introduction. At least, not yet. Not until congestion is so awful that people cry, "Enough… we have to expedite building the high-speed monorail even if that means paying tolls!" The pain level is not yet high enough. We estimated that the hours of congestion on I-70 in Colorado would increase six- to eight-fold so that the highway would be congested all day and most days during the summer and winter seasons within 20 years. The DOE has estimated that the hours spent in traffic congestion is going to triple in the coming years. We're talking real pain, and then FAT corridors will be a real possibility. This timing could work out quite well; it will take ten years for the first high-speed monorail system to be built somewhere and proven attractive, by which time FAT tolls might pass and could be used to finance other systems elsewhere.

G 4

The US has three transportation grids:

- The railways. We have an extensive grid of freight railways that can ship heavy freight long distances. This grid was built in the 19th Century. Many passenger trains running on the freight grid would be a scheduling nightmare, and there is no way that these trains could run on existing tracks at very high speeds, 250 MPH. The top heavy design of conventional trains and the at-grade crossings would not permit it. The French TGV, which runs at up to 186 MPH, uses its own dedicated tracks which are continually worked on to keep perfect alignment.

- The highways. we have a 46,000 mile grid of interstate highways. These are excellent for moving people over short to moderate distances, and for moving freight short to long distances. This grid was built in the 20th Century. This grid is just about at capacity and hours of congestion are increasing rapidly.

- The airways. You have a network of airports that are excellent for moving passengers over great distances. It's also excellent for light-weight or time-sensitive freight. This grid was built in the 20th Century. This grid is just about at capacity; summer 2000 showed that.

It is time for the US to build a fourth grid, G4, a national guideway grid for the high-speed monorail.

It is time for the US to build a fourth grid, G4, a national guideway grid for the high-speed monorail. G4 would serve double duty, for intercity systems, and for metro commuter systems in each of the cities on the national guideway grid. It would be excellent for transporting people short to moderate distances, and it would be excellent for transporting freight over moderate distances, especially light-weight and time-sensitive freight. G4 would be like building another interstate highway system, except that its capacity would be much greater, equivalent to eight or more highway lanes, and the vehicles would run at much higher speeds. It would be the 21st Century grid and it would have capacity sufficient for most of the 21st Century.

Intermodalism is necessary for convenience, so passengers can get from their home to the station, and then from the station to their destination. G4 stations would be hubs for monorails, buses, cars, taxis, and bicycles.

As good as intermodalism is, unimodalism is better. An important part of G4 is ensuring that it serves both metro systems and intercity systems. The concept is for a person to leave one city on its metro system, move seamlessly onto the intercity system, and then seamlessly again onto the metro system in the next city. Quite possibly, the person would never change monorails

G4 would share the interstate right-of-way.

G4 would carry freight: small packages (which is proving a tremendous revenue source for Amtrak), roll-on and roll-off aircraft containers, and there would be freight monorails carrying standard 20' ISO containers. Transit monorails and freight monorails would be completely compatible and would run on the same guideway.

G4 would evolve. High-speed monorail systems would be developed in this region and that, and then would be gradually interconnected into G4. G4 would run down the same rights-of-way that the interstate highway system uses.

G4 may be exciting and big enough to overcome the natural opposition of companies seeking to preserve the status quo, the highway and bridge builders, and the automobile industry. Co-opting the support of these companies may be necessary to avoid a still-birth for G4. There will be tremendous business opportunities and they could all participate. Vehicle manufacturers (automobile and aircraft), bridge builders, engineering contractors, concrete producers, and consulting engineers have obvious opportunities.

It is interesting to think what President George W. Bush's interest in promoting G4 might be. I think it depends if he is a visionary like President Eisenhower, credited with the interstate highway system, or like his father and dismissive of this "vision thing".

Capital Cost. We estimated that the high-speed monorail running up I-70 in Colorado would cost $22 million/mile, including the cost of the guideway, vehicles, special structures such as tunnels, systems, stations, and contingencies. This system was expensive as it twisted and turned up the narrow mountain canyons, and we had to budget for a 1.1 mile double shaft tunnel. Most other systems would cost less.

G4 would be an attractive proposition: capacity equivalent to ten or more highway lanes, with vehicles travelling much faster than on the interstate, and paid for mostly by highway tolls.

The interstate system is 46,000 miles long, 71% is rural and 29% is urban. A goal would be to build a 30,000 mile system, and so a quick cost estimate is:

- $15 million/mile along 21,300 miles of rural interstate. $320 billion.

- $25 million/mile along 8,700 miles of urban interstate (more expensive because of special structures, utility relocation, etc.). $220 billion.

So for $540 billion, all-inclusive, the US could build G4 running along 30,000 miles of the interstate system, adequate for the first half of the 21st Century. $110 billion could be financed by the federal government, and $410 billion by the private sector with FAT bonds serviced by highway tolls.

G4 would be an attractive proposition: capacity equivalent to eight or more highway lanes, with vehicles travelling much faster than on the interstate, and paid for mostly by highway tolls.

GOVERNMENT ACTION

Despite that I have proposed that the private sector take the lead in paying for, building, and running individual high-speed monorail systems, the federal government must take the lead in developing such a national grid. Transit is seen as a risky business by the private sector – it requires too much government and public approval, and governments and the public are fickle. The government needs to take the lead.

Developers of individual transit systems will be focusing on their own system and not thinking about a national grid, so their respective systems could be incompatible. This happened in the early days in Australia: the state of Queensland used a 3'6" gauge for its railway, New South Wales used standard 4' 8½", and Victoria used 5' 3", so you cannot ride one train down the east coast of Australia.

For these reasons the government needs to play a role as standards setter, catalyst, and facilitator, by:

- paying for the initial development of the high-speed monorail to show that it is feasible (the private sector would step in later and develop many vehicles),

- developing national standards for the guideway and vehicles so that all the various regional systems could one day be connected into a national system,

- paying for the initial studies to confirm the worthiness of individual transit projects,

- changing the law (federal and possibly state) so that highway tolls can be used to construct and operate transit systems in the same corridor,

- guaranteeing the FAT bonds, at least partially, that the private sector will buy to pay for these compliant systems, and

- paying some percentage, 20% perhaps, of those transit projects which comply to the national standards.

A VISION

So in my 21st Century crystal ball, I see:

- Many regional high-speed monorail systems, each made up of several metro systems connected by intercity systems,

- FAT corridors with lots of people riding the free monorail and getting there in less time than the toll-paying drivers,

- the private sector heading up the entire effort, paying for the transit system with FAT tolls, running the system for profit, with happy capitalists dealing in hundreds of billions of dollars of FAT bonds, and

- high-density ADR developments every ten miles or so over the major highways within the metro areas,

- fewer green-field developments as people won't want to pay the tolls, and less highway congestion as fewer people will be driving long distances,

- happy politicians who no longer have to pay from public coffers for disruptive and ineffective highway widenings because there is no alternative, and who no longer have to rail against green-field developments. The Democrats will love the fresh air and green spaces, and the Republicans will love the private sector solution and corporate support, and

- G4, a national guideway grid connecting all of the regional high-speed monorail systems.

G4 is technically feasible, economically viable, environmentally desirable, and politically achievable in the 21st Century.

CRITERIA REVISITED & CONCLUSION.

I began by laying out several criteria to judge what could be described as a successful transit strategy for the 21st Century:

- ***Technically Feasible?*** A high-speed monorail that gets you there in less time than driving and which is free (unlike driving with its congestion and tolls) could well divert 25% of the people from the highways onto the transit system.

- ***Economically Viable?*** With capital from the sale of ADRs, with income from the FAT tolls, and with a for-profit operator, the system would be financially viable. It would be entirely possible to have the 80% of the capital cost paid for by the private sector.

- ***Environmentally Desirable?*** Green-field developments between built-up areas, whose only access is by tollway, will be less attractive. Urban and near-urban ADR developments built over covered corridors in a toll-free area and with immediate access to a free high-speed monorail could constitute 50% of future developments.

- ***Politically Achievable?*** The people are in favour of high-speed monorails. Democrats are in favour of transit. When the high-speed monorail proves itself technically and economically viable, and when a strong corporate constituency develops, most Republicans will be in favour. The people may even vote for FAT corridors. And who knows… a charismatic pro-transit leader might step onto the national stage lead us there.

G4, a nationwide guideway grid for the high-speed monorail, is feasible, viable, desirable and achievable in the 21st Century. This may be one of the major opportunities of the 21st Century - there is a clear need, the technology is available, and it could be financed. The political will is what is now needed.

POSTSCRIPT

This paper is a rewrite of an earlier paper, *21ST Century Transit - Feasible? Viable? Desirable? Achievable?* presented to the conference, *New Visions in Transportation*, in Aspen, Colorado October 18-20, 2000.

The Colorado Project: This paper is not about the Colorado project, except that the Colorado project would be the first leg of G4. However, it was cited many times, and so background information on this project may be of interest.

Colorado has a major congestion problem along I-70, connecting Denver metro to the front range and mountain resort communities. I-70 is the lifeline for the state's second largest industry, tourism.

CDOT prepared an MIS in 1997 and 1998 which examined all the alternatives for solving the congestion problem. It concluded that the solution was a fixed guideway system along I-70 along with incremental improvements to the highway.

In 1998, the state legislature set up the Colorado Intermountain Fixed Guideway Authority (CIFGA) to plan the fixed guideway. CIFGA issued an RFP and received seven responses which included proposals for conventional rail, maglev, PRTs, and the high-speed monorail. It evaluated the proposals and selected the high-speed monorail. However, CIFGA has had difficulty winning financial backing for the project.

CIFGA has never been presented nor considered the FAT corridor approach or ADR developments. Those concepts may or may not be relevant to the Colorado I-70 project.